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(54) Micro-positioning actuators

(57) A micro-positioning actuator has in place of the nut and screw of a conventional actuator, a rack and pinion (9,11) or other mechanism that will produce linear motion from rotary motion and a reduction gear train (6) connecting this to an operating motor (2) through a non-reversible drive (4,5) at the motor end. Microswitches (17, Fig. 3) may be provided for limiting the total movement of the output rack (11). In an alternative embodiment (Fig. 5), the pinion (9) meshes with two racks (11,11A) arranged on opposite sides of the pinion.

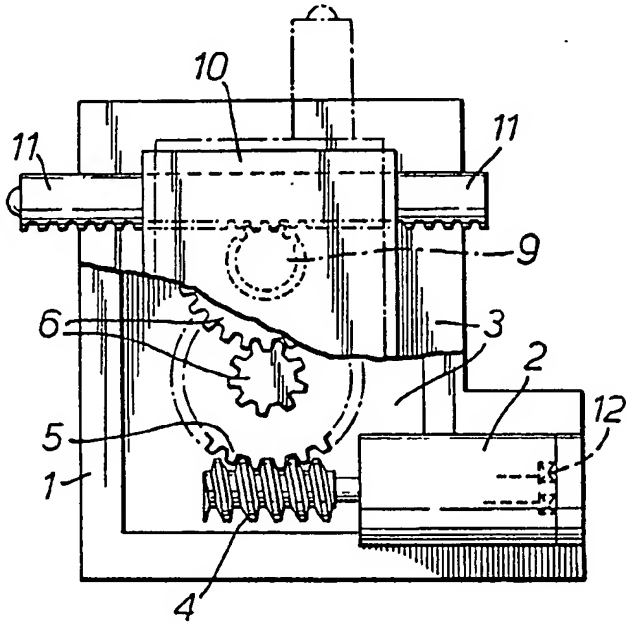

FIG. 1.

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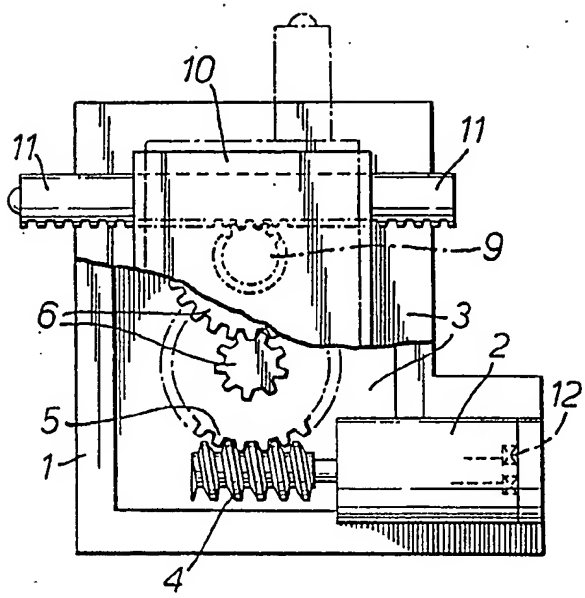

FIG. 1.

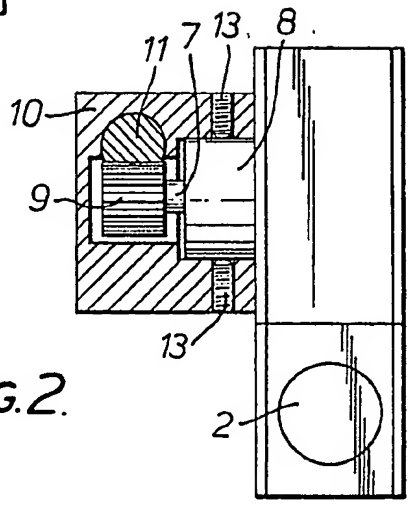

FIG. 2.

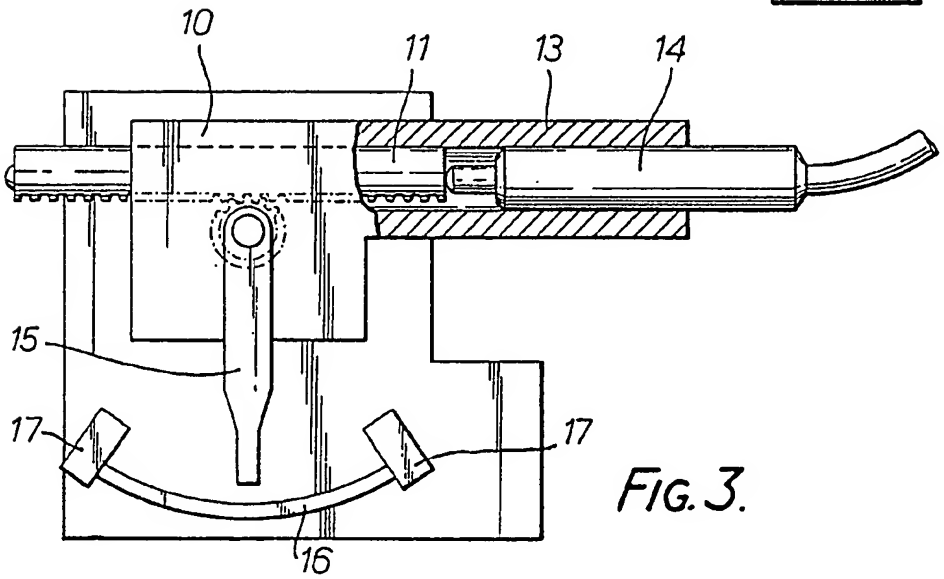

FIG. 3.

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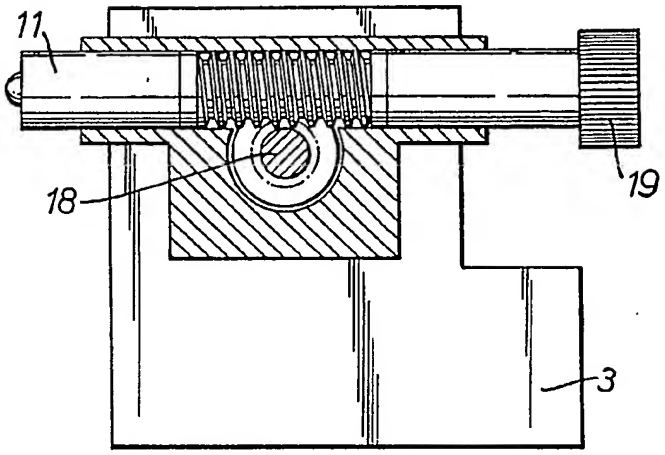

FIG. 4.

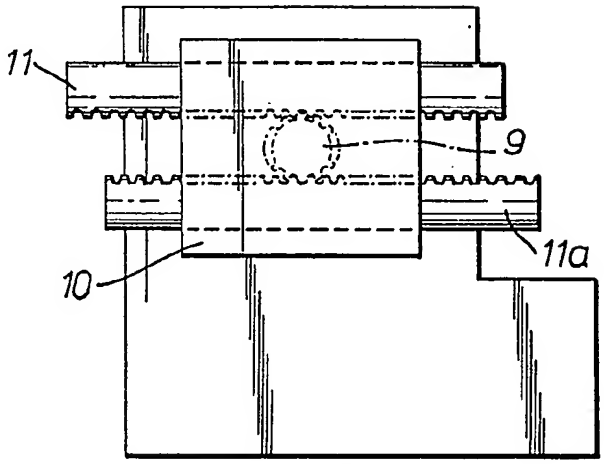

FIG. 5.

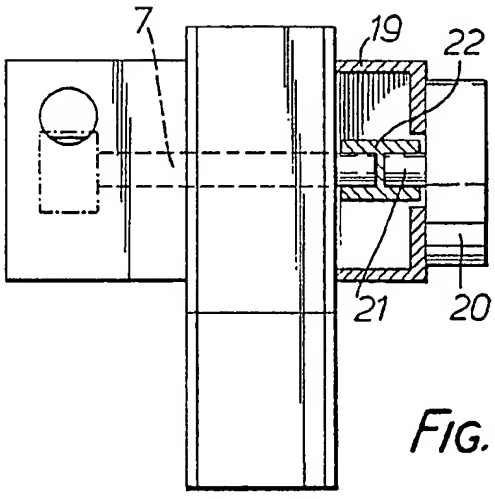

FIG. 6.

SPECIFICATION

Micro-positioning actuators

This invention relates to micro-positioning or micro-manipulation and there is an increasing need for the use of motorised actuators in this connection. The conventional motorised actuator consists of a small D.C. or stepping motor which is connected to a screw and nut assembly through a train of reduction gears, the screw being keyed against rotation so that rotation of the nut produces axial movement of the screw which can then move a linear micro-positioning slide or for example a radius arm of a rotary device. If the slide or radius arm is held against the screw by spring pressure or gravity it is possible to remove backlash from the engagement of the screw and nut. However, backlash is not removed from the key that prevents the screw rotation nor is it removed from the gear train between the nut and motor. Consequently small movements are possible without ambiguity only if they can be made without motor reversal. Since movements 0-0.1 μm are common and typical output backlash figures are of the order of 6-12 μm it is clear that the conventional actuator is unsatisfactory in this respect.

A further disadvantage of the conventional arrangement is that the use of a linearly moving device to produce a rotary motion such as is involved when a radius arm has to be moved is only practicable if the angular motion is restricted to a very small part of a revolution.

Moreover conventional actuators are enclosed with only the end of the screw or an extension of it protruding. This makes access for adjustable limit stops, independent measuring systems etc., inconvenient and the overall length of the unit is directly related to the linear travel so that to produce a range of actuators requires a range of enclosures.

According to the invention an actuator for micro-positioning comprises an input element in the form of a non-reversible drive arranged for being driven by a motor and an output element in the form of a pinion and rack, or pinion and gear segment, and a reduction gear train between said input and output elements, the arrangement being such that loading applied to the output element can take up substantially all the backlash in the drive between said elements. The drive being nonreversible is defined herein in the sense that, although it can be operated both forward and backwardly, motion can only be transmitted from the input to th output, and not from the output to the input.

The non-reversible drive may be a simple worm drive or may be for example a clutch brake drive that may be incorporated in the motor. In one form of clutch brake drive the motor can be held frictionally when de-energised and automatically freed by axial movement of th armature on energisation.

In a preferred form of the invention tne reduction gear train is arranged on pivots in a pair of front and back plates and the output rack or segment is arranged to swing around a boss coaxial with the pinion on a face of one of said plates so as to direct the motion of the rack or segment at a selected angle.

Constructions according to the invention lend themselves to the incorporation of various kinds of sensor for measurement or servo purposes.

For example a linear position sensor can be arranged in a housing to bear on the rear end of the output element, or a rotary sensor such as an encoder or limit switch can be arranged to be driven by part of the reduction gear train, for example by a pinion driving the output rack. Furthermore the output rack may be in the form of a screw thread in which case the pinion is in the form of a worm wheel and the rack can be rotated from the rear end in order to carry out initial adjustments or to cater for manual adjustment in the event of power failure etc.

Several exemplary forms of actuator exhibiting the above and other features of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a partly cut away view of an actuator according to one form of the invention,

Figure 2 is a third angle projection view of the actuator of Figure 1,

Figure 3 is a view similar to Figure 1 of an actuator incorporating a transducer and limit switches,

Figure 4 is a view similar to Figure 1 of an actuator with a manual preset or adjustment for the output element,

Figure 5 is a view similar to Figure 1 of an actuator with two oppositely moving output elements and,

Figure 6 is a view similar to Figure 2 of an actuator fitted with a rotary encoder or transducer.

Referring first to Figure 1 a frame 1 has a bore arranged to receive and locate a motor 2 and is provided with cover plates 3. The motor shaft is fitted with a worm 4 and this drives a worm wheel 5 which operates a reduction gear train 6, in this case consisting of a pair of gears which are carried in pivots in the cover plates 3. The larger of the two gears has a shaft 7 see Figure 2 which extends through a cylindrical boss 8 projecting from one of the cover plates 3 and drives a pinion 9 the axis of which is coaxial with the external surface of the boss 8. A block 10 surrounds the pinion 9 in which the boss 8 is a sliding fit and a transverse bore in the block 10 provides bearings for a rack 11 which meshes with the pinion 9. The leading end of the rack 11 shown to the left of Figure 1 has

a hardened tip for ngaging an object to be moved or positioned and in practise the object is biassed so as to tend to move the rack to the right. This in turn will cause corresponding movements of the gear train 6 and the worm wheel 5, the worm 4 being urged in a direction towards the motor 2 so as to take up all of the backlash in the transmission and the resulting thrust is taken on the thrust bearing 12 of the motor 2.

The block 10 is held in relation to the boss 8 by means of set screws 13 and when these are released it is possible to rotate the block 8 so as to direct the thrust of the rack 11 in any desired direction in one plane. One possible such direction is shown in dotted lines in Figure 1.

The construction lends itself to the fitting of ancillary devices and in Figure 3 a form is illustrated in which the block 10 is extended rearwardly to form a housing 13 for a position sensor 14 which bears against the rear end of the rack 11. The sensor 14 can be either an absolute measuring device or for example a part of a servo system for feeding back position information to a control circuit for the motor 12. The shaft 7 or another shaft in the gear train may be extended as shown in Figure 3 to drive an arm 15 which swings over a track 16 arranged on one of the cover plates 3 to carry a pair of microswitches 17 for limiting the total movement of the output rack 11.

Figure 4 shows a modification of the output rack arrangements where the rack 11 is in the form of a screw threaded member and in this case the pinion 9 is replaced by a worm wheel 18. The rearward end of the rack 11 is extended to a control knob 19 and by this means it can be rotated so as to screw it forward or backwards in relation to the worm wheel 18 in order to achieve an initial setting or to provide manual control in the event of some failure of the motor operation.

Figure 5 shows an arrangement where the pinion 9 in the block 10 meshes simultaneously with two racks 11 and 11A arranged on opposite sides of the pinion. These racks will thus move in opposite directions when the motor is energised and this can provide a convenient arrangement for operating devices where such movement in simultaneous opposite directions is required such as the operation of an optical slit.

Figure 6 shows an arrangement in which the shaft 7 is extended in the opposite direction towards the other of the two cover plates 3 where a housing 19 is provided to which may be attached a rotary encoder 20 for transmitting position information, the encoder shaft 21 being connected to the shaft 7 by means of a coupling sleeve 22.

Although the invention has been described in relation to linearly moving actuators it will be appreciated that a curved rack can also be used so that the operativ end of the rack moves along a circular path. This can be achieved either by having a curved rack fitted within a curved track in the block 10 or if desired the rack may be replaced by a gear segment suitably pivoted at a distance from the pinion 9 and meshing with it.

The invention lends itself to a measure of standardisation since a range of different blocks with output racks having different characteristic features can be arranged to mate with motor and gear units with differing ratios and performance characteristics.

CLAIMS

1. A micro-positioning actuator comprising a housing, an input shaft carried in the housing, a non-reversible drive for the input shaft, a linearly movable output element driven by a pinion on a second shaft, and a reduction gear train between the input shaft and the second shaft.

2. A micro-positioning actuator comprising a housing containing a motor and an input shaft driven by a non-reversible drive from the motor, a linearly movable output element driven by a pinion on a second shaft, and a reduction gear train between the input shaft and the second shaft.

3. A micro-positioning actuator according to Claim 1 or Claim 2, wherein the reduction gear train is arranged on pivots in a pair of front and back plates, and the output element is arranged in a separate second housing which can swing around a boss on the first housing, the boss being coaxial with the pinion on the second shaft.

4. A micro-positioning actuator according to Claim 3, wherein two output elements engage the pinion on opposite sides thereof so as to be moved thereby in opposite directions.

5. A micro-positioning actuator comprising a housing containing an input shaft, a non-reversible drive for the input shaft, a linearly movable output element driven by a pinion on a second shaft, a reduction gear train between the input shaft and the second shaft, and a rearward housing portion for a position sensor having access to the rear end of said linearly movable output element.

6. A micro-positioning actuator according to Claim 5, wherein the reduction gear train is arranged on pivots in a pair of front and back plates, and the output element is arranged in a separate second housing which can swing around a boss on the first housing, the boss being coaxial with the pinion on the second shaft.

7. A micro-positioning actuator according to Claim 6, wherein two output elements engage the pinion on opposite sides th reof so as to be moved thereby in opposite directions.

8. A micro-positioning actuator comprising a housing carrying an input shaft, a non-reversible drive for the input shaft, a linearly mov-

able output element driven by a pinion on a second shaft, a r duction gear train between the input shaft and the second shaft, and a rotary encoder or limit setting device connected to a shaft in the gear train.

9. A micro-positioning actuator according to Claim 8, wherein the reduction gear train is arranged on pivots in a pair of front and back plates, and the output element is arranged in a separate second housing which can swing around a boss on the first housing, the boss being coaxial with the pinion on the second shaft.

10. A micro-positioning actuator according to Claim 9, wherein two output elements engage the pinion on opposite sides thereof so as to be moved thereby in opposite directions.

11. A micro-positioning actuator comprising a housing, an input shaft carried in the housing, a linearly movable output element having a screw thread engaged by a pinion in the form of a worm wheel, a reduction gear train between the input shaft and the second shaft, and means for rotating the output element for manually adjusting same.

12. A micro-positioning actuator according to Claim 11, wherein the reduction gear train is arranged on pivots in a pair of front and back plates, and the output element is arranged in a separate second housing which can swing around a boss on the first housing, the boss being coaxial with the pinion on the second shaft.

13. A micro-positioning actuator according to Claim 12, wherein two output elements engage the pinion on opposite sides thereof so as to be moved thereby in opposite directions.

14. A micro-positioning actuator substantially in any of the forms described with reference to the accompanying drawings.

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ABSTRACT:

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